

Harry J. Watters

THE RADIONUCLIDES OF ARSENIC PRO-
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THE RADIONUCLIDES OF ARSENIC PRODUCED
BY DEUTERON BOMBARDMENT OF GERMANIUM*

by

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*This work has been supported in part by the joint
program of the ONR and AEC, and also in part by the Bureau
of Ordnance, U. S. Navy.

**Now on sea duty, U. S. Navy. Investigation performed
while a U. S. naval postgraduate student at Massachusetts
Institute of Technology, Cambridge, Massachusetts.

June 12, 1953

Note: Not a thesis, but a by-product of
their research. Prepared for publication
in Physical Review.

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THE RADIOLOGICAL ASPECTS OF
BY THE PHYSICS DEPARTMENT OF HARVARD

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An investigation was made of the radionuclides of arsenic produced by the cyclotron bombardment of a thick germanium target with 15 Mev. deuterons. After chemical separation of the arsenic⁽¹⁾, identification of the isotopes present was made by correlating measured values of γ , β^+ , and total β half lives with maximum β energy and γ -ray energy.

Arsenic activity was measured continuously for a period of 53 days with a 4π proportional counter, a γ - γ coincidence counter, and with a thin end window Geiger Muller tube using calibrated aluminum absorbers. Gamma ray energy measurements were made using a thallium-activated sodium iodide scintillation spectrometer. The energy spectrum up to 3 Mev. was scanned continuously for the first 72 hours (Fig. 1) and an additional spectrum was obtained 52 days after bombardment.

By application of the method of least squares to 4π and coincidence counter data, the decay curves were analyzed in a total of four periods: 25.8 hours, 48.2 hours, 17.8 days and 88.9 days. Comparison of total β decay curves with those due only to positron disintegration yielded an additional period slightly greater than 70 hours. These values were verified by analysis of decay curves obtained with the end window β counter. The four experimental components shown in Fig. 2 were obtained from analysis of total β decay observed with the 4π counter.

(1) Brownell, G. L., E. W. Backofen, E. F. White, and J. W. Irvine Jr., M. I. T. Progress Report May 1953, Contract AT(30-1)-952.

with the ΔV counter.

Fig. 3 were obtained from analysis of total β decay observed in window 6 counter. The four experimental components shown in period slightly greater than 70 hours. These values were the only to position discrimination yielded an additional and 32.9 days. Comparison of total β decay curves with those in a total of four periods: 22.8 hours, 43.2 hours, 17.8 days and coincidence counter data, the decay curves were analyzed by application of the method of least squares to ΔV .

Additional spectrum was obtained 32 days after bombardment. scanned continuously for the first 72 hours (Fig. 1) and an α spectrometer. The energy spectrum up to 5 Mev. was

were made using a thallium-activated sodium iodide scintillation calibrated aluminum absorber. Gamma ray energy measurements counter, and with a thin end window Geiger-Müller tube using of 55 days with a ΔV proportional counter, a γ - γ coincidence Arsenic activity was measured continuously for a period

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An investigation was made of the radiochemicals of

The energy of the hardest γ -ray detected with the scintillation spectrometer was 0.85 Mev. with a half life of about 29 hours. An additional γ -ray energy of 0.60 Mev. was resolved several weeks after bombardment.

Maximum β energies were found from absorption curves obtained with the end window β counter. From measurements of maximum range made at various times, the energy of the most energetic β was determined for both the 25.8 hour and the 17.8 day isotopes. In addition mass absorption coefficients were determined from semilog plots of counting rate vs. absorber thickness taken at various times. Using these values, maximum β energies were computed for the 48.2 hour and the 17.8 day isotopes. Close agreement was found for the 17.8 day isotopes by both methods.

Correlation of data indicated that the nuclidic mixture consisted of As^{71} , As^{72} , As^{73} , As^{74} , and As^{77} . Due to the absence of γ -ray energies greater than 0.85 Mev. it was concluded that As^{76} was not present in the mixture.

Since the efficiency of the 4π solid angle β counter constructed for this investigation was shown to be very nearly 100 percent for particles which escape the source, these data were used to determine absolute β activities. These activities were corrected to the time of completion of bombardment and the results specified in terms of yield for each isotope.

The energy of the hardest γ -ray detected with the scintillation spectrometer was 0.85 Mev. with a half life of about 29 hours. An additional γ -ray energy of 0.60 Mev. was resolved several weeks after bombardment.

Maximum β energies were found from absorption curves obtained with the end window β counter. From measurements of maximum range made at various times, the energy of the most energetic β was determined for both the 25.8 hour and the 17.8 day isotopes. In addition mass absorption coefficients were determined from scatter plots of counting rate vs. absorber thickness taken at various times. Using these values, maximum β energies were computed for the 48.2 hour and the 17.8 day isotopes. Close agreement was found for the 17.8 day isotopes by both methods.

Correlation of data indicated that the unstable mixture consisted of As^{71} , As^{72} , As^{73} , As^{74} , and As^{77} . Due to the absence of γ -ray energies greater than 0.85 Mev. it was concluded that As^{76} was not present in the mixture.

Since the efficiency of the 4π solid angle β counter constructed for this investigation was shown to be very nearly 100 percent for particles which escape the source, these data were used to determine absolute β activities. These activities were corrected to the time of completion of bombardment and the results specified in terms of yield for each isotope.

The following is a tabular summary of the results of this investigation:

Isotope	Method of decay	Energy (MeV)	$T_{1/2}$ *	Thick target yield** (uc/uamp-hr)
As ⁷¹	β^+	0.66	48.2 \pm 1.2 hrs.	7.6
As ⁷²	β^+	3.25	25.8 \pm 0.2 hrs.	64.9
	γ	0.85		
As ⁷³	β^-	0.11 $> E_{max} >$ 0.82	86.9 \pm 9.2 days	1.1
As ⁷⁴	β^+			
	β^-	0.99, 1.49	17.82 \pm 0.13 days	5.2
As ⁷⁶		Not present in the mixture		
As ⁷⁷	β^-	< 0.7	> 70 hours	5 $<$ yield $<$ 15***

* Half lives are stated with their respective standard errors.

** The thick target yield values specified apply if the deuteron beam current was exactly 36 uamps and if the arsenic separation efficiency was 100 percent. Yield values quoted are based on β counting only and do not include orbital electron capture.

*** Based on ratios of total β to β^+ counting rates.

The following is a tabular summary of the results of

the investigation:

Isotope	Method of assay	Energy (MeV)	λ (hr ⁻¹)	Yield target (micrograms)
As ⁷¹	+	0.56	48.2 ± 1.5 hrs.	7.6
As ⁷²	+	0.53	35.8 ± 0.3 hrs.	41.9
As ⁷³	-	0.117 0.52	44.9 ± 2.2 days	1.1
As ⁷⁴	+	0.99, 1.49	17.62 ± 0.13 days	8.2
As ⁷⁶	-		Not present in the mixture	
As ⁷⁷	-	0.7	> 70 hours	< 15*

* Based on ratios of total β to β^+ counting rates.

counting only and do not include orbital electron capture.

efficiency was 100 percent. Yield values quoted are based on a beam current was exactly 50 amperes and if the arsenic separation as The label target yield values specified apply if the detectors * Half lives are stated with their respective standard errors.

The Master's thesis "An Investigation of the Radionuclides of Arsenic Produced by Cyclotron Bombardment of Germanium with 15 Mev. Deuterons" submitted by these writers to the Massachusetts Institute of Technology contains details of the investigation and a complete treatment of the construction and operating technique of the $4\pi\beta$ counter. This investigation was suggested by Dr. Gordon L. Brownell of the Massachusetts General Hospital and was conducted under the supervision of Prof. Robley D. Evans.

The author's thesis was investigated by the Massachusetts
of records produced by Division Department of Government with
is now, however, supplied by these writers to the Massachusetts
Institute of Technology contains details of the investigation
and a complete treatment of the construction and operating
mechanisms of the A-7's counter. This investigation was suggested
by Dr. Gordon L. Brownell of the Massachusetts General Hospital
and was conducted under the supervision of Prof. Holley D. Brown.

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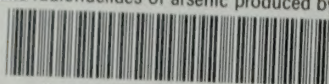
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